



Symmetries in the Universe, a Quanton Origin

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ABSTRACT

The recurrence of high order dimensionless ratios of the physical and cosmological parameters had for long fascinated scientists, Paul Dirac was one of the first to notice this, and after him this phenomena was named (Dirac large number hypothesis), where he tried to explain such a recurrence in terms of varying gravitational constant. here, we will discuss some of the physical or cosmological parameters and their ensuing large number ratios as we will relate them to each other using concepts developed in the (quanton based model of field interactions).

Keywords: *Uniformity and homogeneity of space fabric; large number hypothesis; energy degree of freedom.*

1. INTRODUCTION

Apart from normal matter and radiation energy, the bulk of energy in the universe is in the form of dark energy and dark matter, this division is

based on difference in properties between largely inflationary dark energy and dark matter with mainly gravitational properties, previous research work had suggested that those two entities are nothing but one entity which possesses both the

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properties [1,2,3,4] and even more recent work proposed that dark matter is an exotic form of electromagnetic waves [5].

“The quanton based model of field interactions” [6], introduced the concept of energy constraining, how space and time varying energy fields can evolve in the form of a quantum entity: the quanton.

The two types of fields are free dominated (E_{qt}) and constrained dominated (E_{qc}), they interact inside and outside the quanton, the main mechanism which governs their interaction is energy degree of freedom.

To further illustrate these interactions, three points of interest were chosen (present day, Planck era, single quanton era), so as to derive large number relative ratios for the quanton and cosmological parameters between these different

points, the main variable used when deriving those relationships was the energy density, which is proposed to have a degree of freedom relationship with quanton wave parameters, in doing so it will be shown that the recurrence of high order ratios is not pure coincidence but rather the result of symmetries on the micro scale which found their manifestations on a macro scale [7,8].

2. PHYSICAL BASIS OF THIS MODEL

- a. At any time, quanton frequencies have an energy density which is statistically distributed, and the vacuum energy density equals the summation of those statistically distributed densities.
- b. The quanton frequencies can be replaced by a single equivalent frequency which represents the statistical mean of all quanton frequencies.

2.1 Equations used to Develop this Model

$$r_q = \frac{\lambda}{2} \quad (\text{quanton radius}) \quad (1-2)$$

$$\omega = kc = \frac{\pi c}{r_q}, \quad k = \frac{2\pi}{\lambda} = \frac{\pi}{r_q}, \quad (2-2)$$

$$E_q = h_q \omega^4 \quad (E_q = \text{energy density inside quanton joule/m}^3) \quad (*) \quad (3-2)$$

$$h_q = \frac{h}{16\pi^4 c^3} \quad (h_q : \text{energy density constant}) \quad (*) \quad (4-2)$$

$$E_p = \frac{hc}{2 r_q} \quad (E_p : \text{packet energy, total energy of the quanton in joules}) \quad (5-2)$$

$$N_q = \frac{E_u}{E_p} \quad (N_q : \text{total number of quantons}, \quad E_u : \text{total energy in} \quad (6-2)$$

universe- excluding normal matter and radiation)

$$\rho_v = E_q \quad (7-2)$$

(ρ_v : vacuum energy density, E_q : average energy density inside the quanton)

$$V_q = 8 r_q^3 \quad (V_q : \text{quanton equivalent volume}) \quad (*) \quad (8-2)$$

$$V_u = V_q N_q \quad (V_u : \text{universe volume}) \quad (9-2)$$

$$\rho_v = \frac{E_u}{V_u} \quad (10-2)$$

(*) more details are offered in ref [6]

3. PRESENT DAY PARAMETERS

Present day parameters are suffixed (o)

The methodology followed here is to assess the quanton parameters (ω_o, r_{qo}) while using the energy density / degree of freedom relationship namely $E_{qo} = h_q \omega_o^4$, the energy density of space ρ_{vo} is found to be closer to

$$10^{-29} \text{ gm / cm}^3 \text{ or the equivalent to } 8.65 \times 10^{-10} \text{ j / m}^3 \quad [9]$$

$$\text{Quanton energy density} = E_q = \rho_{vo} = 8.65 \times 10^{-10} \text{ j / m}^3 \quad (1-3)$$

$$\text{Quanton radial frequency } \omega_o = \left(\frac{E_{qo}}{h_q} \right)^{.25} = 1.53 \times 10^{+13} \text{ rad / sec} \quad (2-3)$$

$$\text{Quanton radius} = r_{qo} = \frac{\pi c}{\omega_o} = 6.15 \times 10^{-5} \text{ m} \quad (3-3)$$

$$\text{Quanton volume } V_{qo} = 1.86 \times 10^{-12} \text{ m}^3 \quad (4-3)$$

$$\text{And its packet (total) energy } E_{po} = \frac{h \omega_o}{2 \pi} = 1.61 \times 10^{-21} \text{ j} \quad (5-3)$$

$$\text{Number of quantons per cubic meter} = \frac{V_c}{V_q} = 5.36 \times 10^{11} \quad (6-3)$$

the total mass in the universe is estimated to be close to 10^{53} kgs (based on Hoyle formula

$$M_u = \frac{c^3}{2GH} \quad [10] \quad (7-3)$$

Which corresponds to 10^{70} joules, the equivalent number of quantons is

$$N_{qo} = \frac{E_u}{E_{po}} = 5.9 \times 10^{90} \text{ quantons} \quad (8-3)$$

The corresponding universe's volume = $N_{qo} V_{qo} = 1.1 \times 10^{79} \text{ m}^3$

4. PLANCK ERA PARAMETERS

Planck era parameters are suffixed (p), We note the following

1. The Planck length does not reflect the true dimensions of that era's universe, since it requires an energy density to be of the order of $\frac{E_u}{V_{up}} = \left(\frac{1 \times 10^{70}}{(1.62 \times 10^{-35})^3} \right)$ or approximately 2.35×10^{174} joules/ m^3 which far exceeds the Planck energy density. This leads to the only other alternative, namely the Planck units (length, angular frequency,.) either belong to primordial radiation or the quanton parameters of that era.

2. The relationship between Planck length and Planck angular frequency does not reflect the wave relationship $\omega = kc = \frac{2\pi c}{\lambda}$, instead it defines a relationship $\omega_p L_p = c$
3. The Planck energy density which is theoretically derived and defined as $\frac{E_{pp}}{L_p^3} = 4.63 \times 10^{113} \text{ j/m}^3$ does not take into account the geometry of the quanton which has an equivalent volume that equals $8 L_p^3$, so to obtain the average quanton energy density and subsequently vacuum energy density the Planck energy density has to be divided by a factor of (2^3) , the resulting vacuum density would be

$$\rho_{vp} = 5.79 \times 10^{112} \text{ j /m}^3 \tag{1-4}$$

The angular frequency that corresponds to that energy density

$$\omega_p = \left(\frac{E_{qp}}{h_q}\right)^{.25} = 4.37 \times 10^{+43} \text{ rad /sec} \tag{2-4}$$

And the corresponding quanton radius $r_{qp} = \frac{\pi c}{\omega_p} = 2.15 \times 10^{-35} \text{ m}$ (3-4)

Based on these values , the parameters at the Planck era would become

$$V_{qp} = \text{quanton volume} = 8 r_{qp}^3 = 7.97 \times 10^{-104} \text{ m}^3 \tag{4-4}$$

$$E_{pp} = \text{quanton packet (total) energy} E_{pp} = \frac{h \omega_p}{2\pi} = 4.61 \times 10^{+9} \text{ joules} \tag{5-4}$$

$$\text{Total number of quantons} = \frac{\text{Energy content in the universe}}{\text{Planck era quanton packet energy}} = \frac{E_u}{E_{pp}} = 2.17 \times 10^{+60} \tag{6-4}$$

$$\text{Universe volume } V_{up} = \frac{\text{quanton volume} \times \text{number of quantons}}{\text{volumetric constant}} = V_{qp} N_{qp} = 1.73 \times 10^{-43} \text{ m}^3 \tag{7-4}$$

$$\text{Universe radius } r_{up} = \sqrt[3]{\frac{3 \times V_{up}}{4\pi}} = 3.4 \times 10^{-15} \text{ m} \tag{8-4}$$

Now the relative ratios between present day and Planck era parameters for the quanton and the cosmological parameters can be calculated as shown in Table 1.

Table 1. Various ratios and their relationship to energy degrees of freedom

Relative Ratio	Description	Symbol	Value	Degrees of Freedom	Remarks
Qunton number	$\frac{\text{number of quantons now}}{\text{Planck era nuner of quantons}}$	$\frac{N_{qo}}{N_{qp}}$	2.73×10^{30}	one	
	$\frac{\text{qunton radius now}}{\text{Plank era quanton radius}}$	$\frac{r_{qo}}{r_{qp}}$	2.86×10^{30}	one	
Quanton volume	$\frac{\text{quanton volume now}}{\text{Plank era quanton volume}}$	$\frac{V_{qo}}{V_{qp}}$	2.33×10^{91} $= (2.83 \times 10^{30})^3$	three	
	$\frac{\text{qunton ang. frequency now}}{\text{Plank era ang. frequency}}$	$\frac{\omega_o}{\omega_p}$	2.86×10^{30}	one	
Energy density ratio	$\frac{\text{energy density now}}{\text{Plank era energy density}}$	$\frac{\rho_{vo}}{\rho_{vp}}$	1.49×10^{-122} $= \left(\frac{1}{2.86 \times 10^{30}}\right)^4$	four	
	Universe radius ratio	$\frac{\text{universe radius now}}{\text{Plank era universe radius}}$	$\frac{r_{uo}}{r_{up}}$	$4.46 \times 10^{+40}$ $= (3.07 \times 10^{30})^{\frac{4}{3}}$	$\frac{4}{3}$
Universe radius ratio		$\frac{\text{universe(equivalent) radius now}}{\text{Plank era universe radius}}$	$\frac{r_{ueo}}{r_{up}}$	$4.0 \times 10^{+40}$ $= (2.83 \times 10^{30})^{\frac{4}{3}}$	$\frac{4}{3}$
	Universe volume ratio	$\frac{\text{universe volume now}}{\text{Plank era universe volume}}$	$\frac{V_{uo}}{V_{up}}$	6.37×10^{121} $= (2.82 \times 10^{30})^4$	Four*
Universe to quanton		$\frac{\text{universe radius now}}{\text{quanton radius now}}$	$\frac{r_{uo}}{r_{qo}}$	2.50×10^{30}	

Relative Ratio	Description	Symbol	Value	Degrees of Freedom	Remarks
radii ratio (now)					
Universe to quanton radii ratio (Planck)	$\frac{\text{planck era universe radius}}{\text{Planck era quanton radius}}$	$\frac{r_{up}}{r_{qp}}$	$1.61 \times 10^{+20}$ $(= 2.03 \times 10^{30})^{\frac{2}{3}}$		
Time ratio	$\frac{\text{time now}}{\text{Planck era time}}$	$\frac{t_o}{t_p}$	8.08×10^{60} $= (2.84 \times 10^{30})^2$		(***)

(*) Equivalent spherical shaped universe whose radius = $\sqrt[3]{\frac{3}{4\pi V_u}}$

(**) $\frac{\text{universe radius now}}{\text{quanton radius now}} \left(\frac{r_{uo}}{r_{qo}} \right)$ can be viewed as equal to $\left(\frac{r_{uo}}{r_{up}} \right) \times \left(\frac{r_{up}}{r_{qp}} \right) \times \left(\frac{r_{qp}}{r_{qo}} \right)$

$$= (4.46 \times 10^{40}) (1.61 \times 10^{20}) \frac{1}{(2.86 \times 10^{30})} \tag{9-4}$$

(***) to be discussed in section: parameter variation with time.

It should be noted that

1. By comparing values for the universe volume ratio $\frac{V_{uo}}{V_{up}} = 6.37 \times 10^{121} = (2.82 \times 10^{30})^4$ with the quanton volume ratio $\frac{V_{qo}}{V_{qp}} = 2.33 \times 10^{91} = (2.83 \times 10^{30})^3$, and that of the quanton number ratio (2.73×10^{30}) , one can draw the conclusion that the process of four dimensional quanton energy density expansion into three dimensional space can be achieved through the quanton splitting mechanism [6]
2. When calculating these ratios for present day to Planck era, the normal matter and radiation interactions with space fabric were not taken into account, as a result we can expect the true values to deviate by small percentage from these ideal values.

3. The energy conversion into normal matter affected the relative ratio of the number of quantons more than any other parameter (while disregarding the results of different interactions for now)

5. SINGLE QUANTON ERA

Single quanton era parameters are suffixed (s) Single quanton describes the expansion of the universe starting from a single quanton which is still governed by Planck Einstein relationship, namely $E_u = \frac{hc}{2 r_{qs}}$ and since there is no data about the energy density at the era the starting point would be to obtain the value of single quanton radius r_{qs} .

Under such conditions various parameters of quanton can then be obtained

$$r_{qs} \text{ (quanton radius)} = \frac{hc}{2 E_u} = 9.92 \times 10^{-96} \text{ m} \tag{1-5}$$

$$\omega_s = \frac{\pi c}{r_{qs}} = 9.93 \times 10^{+103} \text{ rad /sec} \tag{2-5}$$

$$\text{quanton volume } V_{qs} = 8 r_{qs}^3 = 7.81 \times 10^{-285} \text{ m}^3 \tag{3-5}$$

(same as the volume of universe of that era V_{us})

$$e_{vs} \text{ (energy density)} = E_{qs} = \frac{E_u}{V_{qs}} = 1.279 \times 10^{+354} \text{ j / m}^3 \tag{4-5}$$

Those values lead to the development of another set of ratios this time relating them to Planck era as is shown in Table.2

Table 2. Various ratios (Planck era parameters to that of single quanton) and their relationship to energy degrees of freedom

Relative ratio	Description	Symbol	Value	Degrees of freedom	Remarks
Number of Quntons	= planck era quanton number	$\frac{N_{qp}}{N_{qs}}$ = N_{qp}	2.16×10^{60}	one	
Quanton radius	$\frac{\text{Planck era quanton radius}}{\text{single quanton radius}}$	$\frac{r_{qp}}{r_{qs}}$	2.16×10^{60}	one	
Quanton volume	$\frac{\text{Planck era quanton volume}}{\text{single quanton volume}}$	$\frac{V_{qp}}{V_{qs}}$	1.01×10^{181} $= (2.16 \times 10^{60})^3$	three	
Angular frequency	$\frac{\text{single quanton ang. frequency}}{\text{Planck era ang. frequency}}$	$\frac{\omega_s}{\omega_p}$	2.16×10^{60}	one	
Energy density ratio	$\frac{\text{single quanton energy density}}{\text{Planck energy density}}$	$\frac{\rho_{vs}}{\rho_{vp}}$	2.21×10^{241} $= (\frac{1}{2.16 \times 10^{60}})^4$	four	
Universe radius ratio	$\frac{\text{Planck era universe radius}}{\text{single quanton radius}}$	$\frac{r_{up}}{r_{qs}}$	$2.80 \times 10^{+80}$ $= (2.16 \times 10^{60})^{\frac{4}{3}}$	$\frac{4}{3}$	(*), (**)
Universe volume ratio	$\frac{\text{Planck era universe volume}}{\text{single quanton volume}}$	$\frac{V_{up}}{V_{us}}$	2.21×10^{241} $(2.16 \times 10^{60})^4$	Four*	

(*) For the particular case of single quanton

the universe's radius is defined as $r_{us} = r_{qs} \sqrt[3]{\frac{6}{\pi}}$ ($N_{qs} = 1$) (5-5)

and the volume of the universe $= \frac{4\pi}{3} r_{us}^3 = 8 r_{qs}^3 = \text{quanton volume}$

(**) It is interesting here to note that the ratio of the radii of the universe to quanton ($\frac{r_u}{r_q}$) changes as follows

Single quanton : $\frac{r_{us}}{r_{qs}} = \sqrt[3]{\frac{6}{\pi}}$ (6-5)

Planck era $\frac{r_{up}}{r_{qp}} = (2.03 \times 10^{30})^{\frac{2}{3}} = \sqrt[3]{(\frac{6}{\pi} \times 2.17 \times 10^{60})} = \sqrt[3]{(\frac{6}{\pi} N_{qp})}$ (7-5)

Present day, equivalent sphere radius defined as $r_{ueo} = \sqrt[3]{\frac{3V_u}{4\pi}}$ (8-5)

$\frac{r_{ueo}}{r_{qo}} = 2.24 \times 10^{30} = \sqrt[3]{(\frac{6}{\pi} \times 5.9 \times 10^{90})} = \sqrt[3]{(\frac{6}{\pi} \times N_{qo})}$ (9-5)

at any instance in time ,the radii ratio $\frac{r_u}{r_q} = \sqrt[3]{\frac{V_u}{V_q}} = \sqrt[3]{\frac{N_q V_q}{V_q}}$ (10-5)

$= \sqrt[3]{\frac{N_q (8 r_q^3)}{\frac{4\pi}{3} r_q^3}} = \sqrt[3]{\frac{6 N_q}{\pi}}$ which corresponds to one-third Dof (11-5)

The universe radius (viewed as an equivalent sphere) is proportional to the cubic root of the number of quantons multiplied by quanton radius, in other words the universe volume which is represented by four degrees of freedom is the result of quanton volumetric expansion (represented by three degrees of freedom) and quanton splitting (represented by one Dof)

We can add to those ratios another one that relates to time ratio based on symmetry of behavior of energy expansion between

$$\frac{t_p}{t_s} \text{ (calculated)} = \frac{\text{planck time}}{\text{single quanton time}} = 4.7 \times 10^{120} = (2.17 \times 10^{60})^2 \quad (12-5)$$

$t_s = 1.15 \times 10^{-164}$ sec (Time needed for quanton to evolve from an packet state (energy not varying in space or time) which is defined as $E_p = E_s E_t$ to become a single quanton in the form $E_q = (E_{sf} E_{tc})(E_{sc} E_{tf})$).

Another important remark here that's the energy content of the universe (and consequently energy density) alters the quanton parameters (and consequently the cosmological parameters), but it does not alter quanton or cosmological symmetries as this energy content of the universe acts only as a scale-up or scale -down factor, in other words symmetries are preserved irrespective of the energy content or the energy density of vacuum.

The first question the single quanton model arises is where did the radiative energy required for nucleosynthesis come from ?

It would be too cold for normal matter to evolve under such model.

The quanton based model's main conclusion was that the CMB radiation was a direct result of the free expansion of the space fabric.

while the thermodynamics of quanton inflation and splitting remains unstudied subject till now , the attention must be drawn to the two facts:

- a. The minuscule dimensions of the Planck era's universe (10^{-15} m)
- b. b-And the very fast ratio of quanton splittings ($= 2.17 \times 10^{60}$)

Although quantons split asymmetrically , an ideal case whereby the quanton splits symmetrically can be discussed here quanton splitting cycle

corresponds to the time needed (Δt) for every quanton to undergo a single splitting event, in other words, if the number of quantons N_q can be put in the form

$$N_q = 2^m \quad (13-5)$$

this corresponds to (m) splitting cycles , based on the obtained results for total

$$\text{number of quantons } N_q(t_o) = 1.06 \times 10^{91} = 2^m \quad (14-5)$$

$$\text{Solving for m , result in } m = 302 \text{ cycles} \quad (15-5)$$

For the number of Planck era splittings

$$N_q(t_{Planck}) = 2.17 \times 10^{60} = 2^m \quad (16-5)$$

$$\text{Again solving form, result in } m = 200 \text{ cycles} \quad (17-5)$$

Out of those 300 splitting cycles about 200 cycles occurred in a time equal to Planck time (which is equivalent to double order of magnitude of the splitting that occurred throughout the remaining life span of the universe till now),

These figures might be helpful in understanding , for now , where the source of the primordial of radiation came from

6. TIME VARIATION-ENERGY DEGREE OF FREEDOM RELATIONSHIP

The time variation ratio $(\frac{t_o}{t_p}) = 8.08 \times 10^{60} = (2.84 \times 10^{30})^2$, is not a coincidence , quanton physical parameter ratios and consequently cosmological physical parameter ratios are strictly tied to time ratio and due to this fact , we can relate all the quanton parameters and consequently the cosmological parameter variations to time variation to obtain a profile of the parameter variation with time.

At the origin of this symmetry is the relationship between the quanton wave parameters ω, r_q and time variation.

Variation of time is split anti symmetrically and equally between the time and space varying quanton wave parameters, and as we are dealing with energy degrees of freedom which take an exponential form , this division of time variation takes the form $(\sqrt[2]{t})$ square root proportionality the quanton radius can be put as

$$r_q = K_r \sqrt[2]{t} \quad (1-6)$$

$$\text{and the angular frequency } \omega = \frac{K_\omega}{\sqrt{t}} \quad (2-6)$$

K_r, K_ω are time constants of the quanton radius and angular frequency and this antisymmetric division allowed for the wave behavior of the quanton to be preserved.

As the quanton wave parameters are linked together by an antisymmetric variation of time, all

the other quanton parameters (quanton packet energy, energy density, and volume) are interconnected by the energy degree of freedom relationship which is related to the quanton parameters.

To define the various quanton and cosmological parameters' variation with time, it must be done in terms of their respective energy degrees of freedom as follows

$$\text{Dof}_{r_q} = 1 = \text{Dof}_\omega = \frac{1}{2} \text{Dof}_t \quad \text{or} \quad \text{Dof}_t = \text{Dof}_{r_q} + \text{Dof}_\omega = 2 \quad (3,4-6)$$

$$\text{Dof}_{V_q} \text{ (quanton volume)} = 3 \text{Dof}_{r_q} = \frac{3}{2} \text{Dof}_t, \quad (5-6)$$

$$\text{Dof}_{N_q} \text{ (number of quantons)} = 1 = \frac{1}{2} \text{Dof}_t \quad (6-6)$$

$$\text{Dof}_{V_u} = 4 = 4 \text{Dof}_{r_q} = 2 \text{Dof}_t, \quad (7-6)$$

$$\text{Dof}_{r_u} \text{ (universe radius)} = \frac{1}{3} \text{Dof}_{V_u} = \frac{4}{3} = \frac{2}{3} \text{Dof}_t \quad (8-6)$$

$$\text{Dof}_{\rho_v} \text{ (energy density)} = 4 \text{Dof}_{r_q} = 4 = 2 \text{Dof}_t \quad (9-6)$$

In general a parameter (x) varies in time according to

$$x(t) = K_x t^{+/-\left(\frac{\text{Dof}_x}{2}\right)} \quad (10-6)$$

To preserve the wave behavior the constants K_r, K_ω must be related such that

$$r_q = \frac{\pi c}{\omega} \quad \text{hence} \quad K_r K_\omega = \pi c \quad (11-6)$$

$$\text{Other wave relations still apply Wave period : } T(t) = K_T \sqrt{t} \quad (12-6)$$

$$\text{wave number } k = \frac{K_k}{\sqrt{t}}, \quad (13-6)$$

$$\frac{2\pi K_r}{K_T} = c \left(= \frac{\lambda}{T} \right), \quad \frac{K_\omega}{K_k} = c \left(= \frac{\omega}{k} \right) \quad (14,15-6)$$

$$K_T K_\omega = 2\pi (= \omega T), \quad K_k K_r = 1 \left(= \frac{k\lambda}{2\pi} \right) \quad (16,17-6)$$

7. QUANTON AND COSMOLOGICAL PARAMETER VARIATION WITH TIME

1-Number of quantons: N_q , with a ratio (2.73×10^{30}) should be ideally related to time variation by the relationship $N_q(t) = K_n t^{\frac{1}{2}}$ (1-7)

$N_q(t)$: number of quantons at any time (t)

$$\frac{N_q}{dt} = \frac{1}{2} K_n t^{-\frac{1}{2}}, \quad K_n : \text{constant of proportionality} \quad (2-7)$$

2-Quanton radius $r_q(t) = k_{r_q} t^{\frac{1}{2}}$ (3-7)

$$\frac{dr_q}{dt} = \frac{1}{2} K_r t^{-1} \tag{4-7}$$

3- Quanton angular frequency $\omega(t) = K_\omega t^{-1}$ (5-7)

$$\frac{d\omega}{dt} = \frac{-1}{2} K_\omega t^{-2} \tag{6-7}$$

Alternatively $\omega(t) = \frac{\pi c}{r_q} = \frac{\pi c}{K_r t^2}$ ($K_\omega = \frac{\pi c}{K_r}$) (7-7)

$$\frac{d\omega}{dt} = \frac{d\omega}{dr_q} \frac{dr_q}{dt} = \left(\frac{-\pi c}{r_q^2}\right) \left(\frac{1}{2} K_r t^{-1}\right) = \left(\frac{-\pi c}{K_r^2 t}\right) \left(\frac{1}{2} K_r t^{-1}\right) = \frac{-\pi c}{2 K_r t^2} \tag{8-7}$$

4- Quanton packet energy $E_p(t) = \frac{h\omega}{2\pi} = \frac{1}{2\pi} K_\omega h t^{-1}$ (9-7)

$$\frac{dE_p}{dt} = \frac{-K_\omega h t^{-2}}{4\pi} = \frac{-hc}{4 K_r} t^{-3} \tag{10-7}$$

5-Quanton volume $V_q(t) = K_{vq} t^3$ (11-7)

$$\frac{dV_q(t)}{dt} = \frac{3}{2} K_{vq} t^2 \tag{12-7}$$

6- Energy density $\rho_v(t) = K_\rho t^{-4} = K_\rho t^{-2}$ (13-7)

$$\frac{d\rho_v}{dt} = -2 K_\rho t^{-3} \tag{14-7}$$

8. RELATIONSHIP BETWEEN QUANTON AND COSMOLOGICAL PARAMETER VARIATION

The universe volume, its radius and the prevailing energy density are all related to the quanton parameters , the microscopic process that involves expansion and splitting of quantons leads to the macro scale in the form of the universe's inflation and progressive energy density reduction.

Those cosmological parameters are also governed by time / degree of freedom relationship.

Each one of these parameters has its own time variation as shown before, these relationships are defined as

$$\frac{dV_u}{dt} = \left(N_q \frac{dV_q}{dt} + \frac{dN_q}{dt} V_q \right) \tag{3-8}$$

$$= \left[\left(K_n t^2 \right) \left(\frac{3}{2} K_{vq} t^2 \right) + \left(\frac{1}{2} K_n t^{-1} \right) \left(K_{vq} t^3 \right) \right] \tag{4-8}$$

$$\frac{dV_u}{dt} = (K_n K_v) \left(\frac{3}{2} t + \frac{1}{2} t \right) = 2 K_n K_v t = 2 K_{vu} t \tag{5-8}$$

and for the radius of the universe r_u while expanding as a sphere

$$V_u(t) = \text{universe volume at any time } (t) = N_q(t) V_q(t)$$

$$= (K_n t^2) (K_{vq} t^3) = K_n K_{vq} t^5 = K_{vu} t^2 \tag{1-8}$$

Where $K_{vu} = K_{vq} K_n$ (2-8)

This is a second order variation of the volume of universe with time which corresponds to expansion of energy density with four degrees of freedom. This relationship between the universe's volume and that of the quanton parameters is the product of a quanton expansion which corresponds to three degrees of freedom and splitting of the quantons which corresponds to one degree of freedom. The rate of the volumetric expansion of the universe.

$$r_u = \sqrt[3]{\frac{3}{4\pi} V_u} = \sqrt[3]{\frac{3V_q N_q}{4\pi}} = r_q \sqrt[3]{\frac{6}{\pi} N_q} \quad (6-8)$$

$$r_u(t) = (K_{rq} t^{0.5}) \left(\sqrt[3]{\frac{6K_n}{\pi}} t^{\frac{1}{2+3}} \right) = K_{rq} \sqrt[3]{\frac{6K_n}{\pi}} t^{\frac{2}{3}} \quad (7-8)$$

$$= K_{ru} t^{\frac{2}{3}} \quad (8-8)$$

$$K_{ru} = K_{rq} \sqrt[3]{\frac{6K_n}{\pi}} \quad (9-8)$$

$$\frac{dr_u}{dt} = \frac{2}{3} K_{ru} t^{-\frac{1}{3}} \quad (10-8)$$

As all the quanton and cosmological parameters are synchronized via the degree of freedom – time relationship, the developed time constants (K's) can be used to chart the history of the parameter variation

9. ANALYTICAL DETERMINATION OF THE TIME CONSTANTS

The estimation of the value of time constants (K's) is not a curve fitting process, given that we have a reliable data about one point in time we can estimate those constants in terms of other physical and geometric constants For the period (single quanton to Planck era), the various constants can be defined as

$$r_{qs} = \text{quanton radius} = K_{rq} \sqrt{t_s} = \frac{hc}{2E_u}$$

$$K_{rq} = \frac{hc}{2E_u \sqrt{t_s}} \quad (1-9)$$

(t_s : time to single quanton , E_u : universe's total energy)

$$\omega_s = \frac{K_w}{\sqrt{t_s}} = \text{angular frequency at single quanton era} = \frac{2\pi E_{ps}}{h}$$

E_{ps} = quanton packet energy (at single quanton era) = E_u ,

$$K_w = \frac{2\pi \sqrt{t_s} E_u}{h} \quad (2-9)$$

$$V_{qs} \text{ (quanton volume at S.Q)} = 8 r_{qs}^3 = K_{vq} t_s^{\frac{3}{2}} \quad (3-9)$$

$$K_{vq} = 8 K_{rq}^3 \quad (4-9)$$

$$\rho_{vs} = E_{qs} = \text{vacuum energy density at single quanton era} = \frac{K_{qv}}{t_s^2} = \frac{E_{ps}}{V_{qs}}$$

$$K_{qv} = \frac{h K_w^4}{16 \pi^4 c^3} \quad (4-9)$$

$$N_{qs} = \text{number quantons} = K_n \sqrt{t_s} = \text{one}$$

$$K_n = \frac{1}{\sqrt{t_s}} \quad (5-9)$$

While the quanton packet energy can be alternatively defined as

$$E_p = \frac{E_u}{N_q} = \frac{E_u}{K_n \sqrt{t}} = \frac{hK_w}{2\pi\sqrt{t}}, \text{ which yields}$$

$$K_w = \frac{2\pi E_u}{h K_n} \quad \text{and} \quad K_{rq} = \frac{hc K_n}{2 E_u} \tag{6-9}$$

Those two relations lead to the following definitions of the quanton radius and

$$\text{angular frequency } r_q = \frac{hc}{2\pi E_u} \sqrt{\frac{t}{t_s}}, \quad \omega = \frac{2\pi E_u}{h} \sqrt{\frac{t_s}{t}} \tag{7,8-9}$$

and as to the cosmological parameters

$$V_u = V_q N_q \text{ which leads to } K_{vu} = K_{vq} K_n \tag{9-9}$$

While expanding into a sphere, the radius of the universe

$$r_u = \sqrt[3]{\frac{3}{4\pi} V_u} = \sqrt[3]{\frac{3}{4\pi} V_q N_q} \tag{10-9}$$

$$K_{ru} = \sqrt[3]{\frac{3}{4\pi} K_{vq} K_n} = K_{rq} \sqrt[3]{\frac{6}{\pi} K_n} \tag{11-9}$$

$$\text{And } \frac{r_u}{r_q} = \sqrt[3]{\frac{6}{\pi} N_q} \text{ as before} \tag{12-9}$$

10. INFLATIONARY HISTORY OF THE UNIVERSE

Degree of freedom expansion of energy density in space is not restricted to micro scale as it is inside the quanton, but rather is extended to the macro scale or the cosmological level. This mechanism predisposes the expansion of space fabric to be in a spatially symmetrically shape, which restricts the inflation of the universe to be either in the form of sphere or shell.

The inflationary history of the universe comprises two phases

10.1 Inflation in a Spherically Shaped Universe

Under which the rate of change of its comoving radius is $\frac{dr_u}{dt} > c$

the radius of the spherically shaped universe (where $V_u = K_{vu} t^2$)

$$\text{is defined as } r_u = \sqrt[3]{\frac{3}{4\pi} V_u} = \sqrt[3]{\frac{3}{4\pi} K_{vu} t^2} = K_{ru} t^{\frac{2}{3}} \tag{1-10}$$

and the rate of change of the universe radius is defined as

$$\frac{dr_u}{dt} = \frac{d}{dt} (K_{ru} t^{\frac{2}{3}}) = \frac{2}{3} K_{ru} t^{-\frac{1}{3}} \tag{2-10}$$

For earlier period of the universe's inflationary history (and especially for very small values of $t < 1$ second) the rate of change of the universe radius ($\frac{dr_u}{dt}$) was much greater than the constant (c).

Under primordial conditions, the universe radius grew from the dimensions of single quanton to that of the Planck era world by

a 10^{80} fold and then by a further 10^{30} fold in just one second. As time passed, the rate of change of the universe radius dropped dramatically, which was viewed as a decelerating universe, until this rate of change of the universe's radius ($\frac{dr_u}{dt}$) reached value equal to (c), this instant corresponds to the transition time (t_r) defined as

$$\frac{dr_u}{dt} = c = \frac{2}{3} K_{ru} t_r^{-\frac{1}{3}} \quad , \quad t_r = \left(\frac{2K_{ru}}{3c}\right)^3 \quad (3, 4-10)$$

Transition time t_r = about 5 billion years, Beyond that the universe no longer follows the spherically shaped pattern.

For that era (spherically shaped) the universe radius , volume and their rates of change with time are

$$1 - \frac{dV_u}{dt} = \frac{dV_u}{dr_u} \frac{dr_u}{dt} = 2K_{vu}t = (4\pi r_u^2)\left(\frac{2}{3} K_{ru}t^{-\frac{1}{3}}\right) = \frac{8\pi}{3} K_{ru}^3t \quad (4-10)$$

And the Hubble parameter of that era would be equivalent to

$$H(t) = \frac{\frac{dr_u}{dt}}{r_u} = \frac{\frac{2}{3}K_{ru}t^{-\frac{1}{3}}}{K_{ru}t^{\frac{2}{3}}} = \frac{2}{3t} \quad \text{for} \quad t < t_r \quad (5-10)$$

(Here the universe radius will be taken as a representative of the scalar

$$\text{Parameter (a)) or } \frac{dr_u}{r_u} = \left(\frac{\dot{a}}{a}\right) \quad (6-10)$$

This is the same solution of Friedmann's equations for matter dominated and decelerating universe (Einstein-De sitter model)

it's worth noting that the transition time is dependent on the energy content of the universe.

10.2 Inflation as a Shell Shaped

As the comoving rate of $\left(\frac{dr_u}{dt}\right)$ for a spherically shaped universe decelerates to velocities $< c$ beyond $t = t_r$, the inflationary momentum of the space fabric takes over as the driving force behind inflation (keeping in mind that quanton fields must expand at a fixed velocity that equals to c) , and from that instant on ,the universe expands at a constant velocity $\frac{dr_o}{dt} = c$, as this happened the shape of the universe no longer followed the spherical model , but rather it became a shell shaped.

Space fabric volume is defined by a hypothetical equivalent sphere whose radius

$$r_{rue} = K_{ru} t^{\frac{2}{3}} \quad , \quad t > t_r \quad (7-10)$$

shell shaped universe has an outer radius (r_o) and inner radius (r_i)

This happens as the volume created by the outer radius (r_o) (that expands at fixed velocity $=c$) which equals to $V_{uo} (= \frac{4\pi}{3} r_o^3)$ becomes greater than the volume space fabric itself (defined as $V_u = K_{vu} t^2$)

The universe volume , and its radius are related by the following equations

$$1. \quad r_o(t) (\text{outer radius}) = c (t-t_r) + K_{ru} t_r^{\frac{2}{3}} \quad (8-10)$$

V_u (volume of the shell shaped universe)

$$2. \quad = K_{vu} t^2 = \frac{4\pi}{3} (r_o^3 - r_i^3) \quad (9-10)$$

$$3. \quad \frac{dV_u}{dt} = \frac{dV_u}{dr_o} \frac{dr_o}{dt} = 2K_{vu}t = \left(\frac{dV_u}{dr_o} \frac{dr_o}{dt} - \frac{dV_u}{dr_i} \frac{dr_i}{dr_o} \frac{dr_o}{dt}\right)$$

$$= 4\pi (c r_o^2 - c r_i^2 \frac{dr_i}{dr_o}) = 4\pi c (r_o^2 - r_i^2 \frac{dr_i}{dr_o}) \tag{10-10}$$

Those three equations have three unknowns r_o , r_i , $\frac{dr_i}{dr_o}$ (given that we have already postulated that $\frac{dr_o}{dt} = c$), when solving for present day values the following results are obtained

$$r_o = 1.54 \times 10^{26} \text{ m} , r_i = 1.01 \times 10^{26} \text{ m} , \frac{dr_i}{dr_o} = 1.01 \tag{11-10}$$

While the value of $\frac{dr_i}{dr_o}$ is always greater than zero in magnitude and assumes positive values, as negative values indicate narrowing inner void , positive values lesser than one indicate an outer radius growing at a higher rate than the inner radius, while values greater than one indicate a void inner radius which is growing at a rate greater than that of the outer radius – which is the case of progressively thinning shell.

Ratios of outer and inner radii and their relative rate can be plotted versus time as shown in Fig.1, Fig. 2.

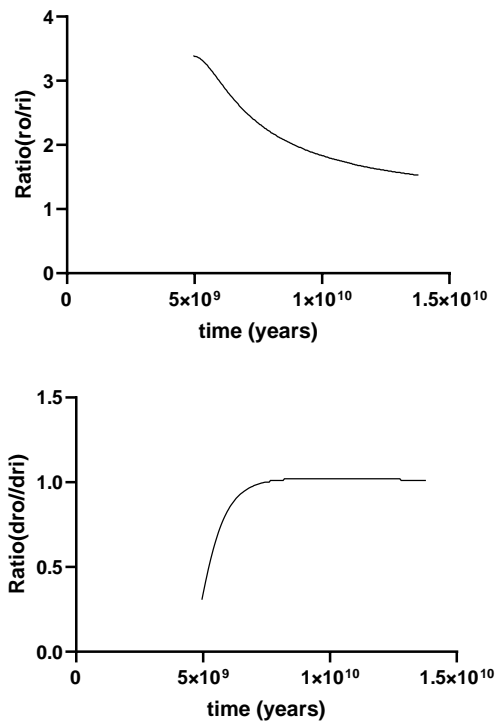


Fig. 1. and Fig. 2. Relative ratio between the universe outer and inner radii and their rates of change versus time

Alternatively, it can be shown that the volume enclosed by the outer radius increases at a rate that equals

$$\frac{dV_{uo}}{dt} = \frac{d}{dt} \left(\frac{4\pi}{3} r_o^3 \right) = 4\pi r_o^2 \frac{dr_o}{dt} , \tag{12-10}$$

$$\frac{dr_o}{dt} = \frac{d}{dt} [c (t-t_r) + K_{ru} t_r^{\frac{2}{3}}] = c \tag{13-10}$$

$$\frac{dV_{uo}}{dt} = 4\pi c [c (t - t_r) + K_{ru} t_r^{\frac{2}{3}}]^2 \text{ which is proportional to } (t^2) \tag{14-10}$$

While space fabric expands at the rate of $\frac{dV_u}{dt} = 2 K_{V_u} t$ which is proportional to (t) The current values are $\frac{dV_{u0}}{dt} = 8.94 \times 10^{61} \text{ m}^3/\text{sec}$ and for $\frac{dV_u}{dt} = 5.05 \times 10^{61} \text{ m}^3/\text{sec}$ which indicates a lower rate of space fabric volumetric expansion than that of the outer sphere expansion , and this gap between the two expansion rates is widening with time

The relative ratios between outer sphere vs universe volume and their rates of change can be plotted against time as shown in Fig. 3, Fig. 4.

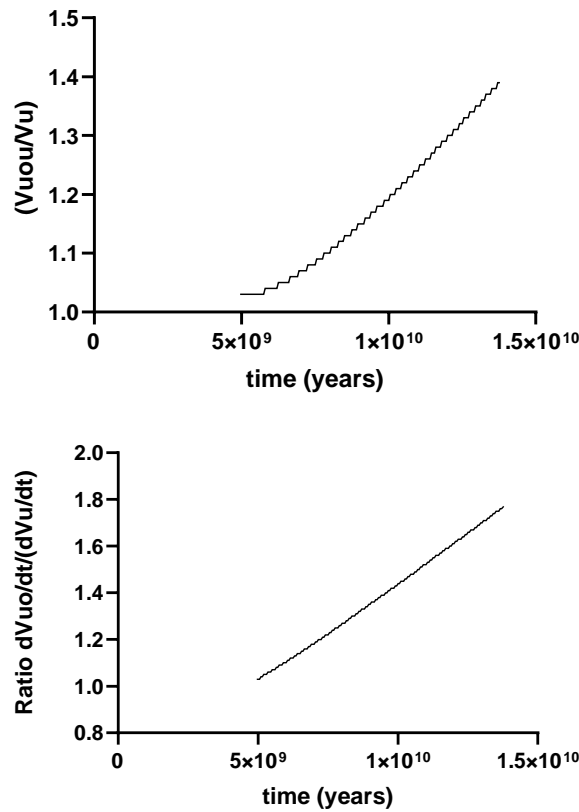


Fig. 3. and Fig. 4. Ratio between volumes of outer sphere and space fabric and consequently their rates which are increasing with time

An upper, mean , and a lower value of the Hubble parameter can then be

established given that $r_m = \frac{1}{2}(r_0 + r_i)$, $\frac{dr_m}{dt} = \frac{c}{2} (1 + \frac{dr_i}{dr_0})$ (15,16-10)

Lower limit : $H_L(t) = \frac{dr_0}{dt} = 1.94 \times 10^{-18} \text{ m.sec}^{-1}/\text{m}$ which corresponds to a value of 60.1 km/sec/mega parsec

Mean value $H_m(t) = \frac{dr_m}{dt} = \frac{dr_m}{dr_0} \frac{dr_0}{dt} = 2.36 \times 10^{-18} \text{ m/sec/m}$ (17-10)

which corresponds to a value of 72.8 km/sec/mega parsec While the upper limit $H_u(t) = \frac{dr_i}{dt} = \frac{dr_i}{dr_0} \frac{dr_0}{dt} = 2.99 \times 10^{-18} \text{ m/sec/meter} = 92.8 \text{ km/sec/ mega parsec}$ (18-10)

This value is physically meaningless as it relates to the expansion of the inner void

The direct result one can draw from these values is the relative nature of the Hubble parameter since the uniformity and homogeneity of space fabric does not translate into uniformity of inflation, but it reflects uniformity of volumetric expansion of space fabric, as the relative values of the Hubble parameter reflect the progressive thinning of the shell.

Instead, the CMB red shift can be used as an alternative means of assessing the inflation of the universe where

$$H_o \text{ (CMB)} = \frac{c}{r_{ueo}} \tag{19-10}$$

r_{ueo} : radius of the equivalent sphere at present day = 1.38×10^{26} m

For the current values $H_o \text{ (CMB)} = 2.17 \times 10^{-18}$ m/sec/meter which is equivalent to 67.3 km/sec/mega parsec.

The following figures show variation of the Hubble parameter for the CMB case (Fig. 5.) and for inner and outer radii of the universe (Fig. 6.)

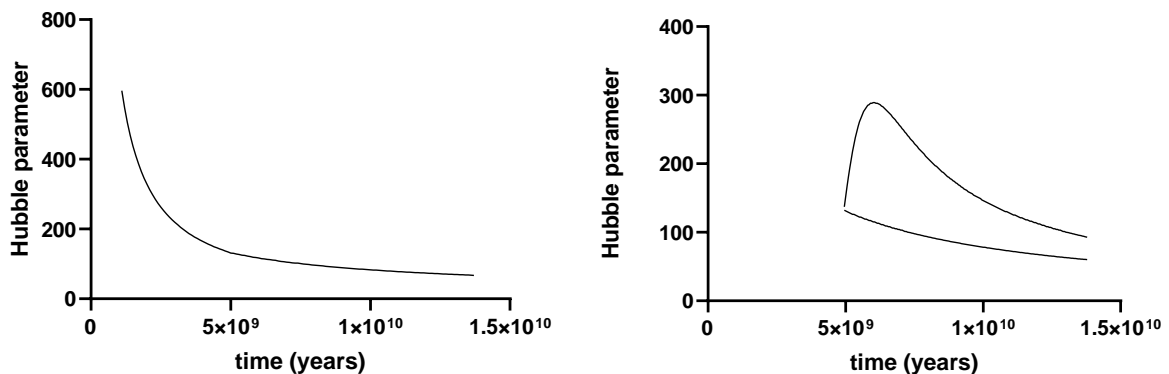


Fig. 5. Hubble parameter for cosmic microwave background H(CMB) versus time, while Fig. 6. shows Hubble parameter for both the inner and outer radii versus time

10.3 Observational Findings

recent research works indicate that

- 1- the universe is closed in contrast to the long held view of a flat universe [11,12]
- 2.a- expansion rate of the universe is not the same everywhere.
- 2.b-and more importantly , there is a directional dependence of the expansion rate. [13,14]

11. POSSIBLE INFLATIONARY MODELS

We have discussed only a single inflationary model of the form (a) $\propto t^{\frac{2}{3}}$, to allow for a complex model , with different inflationary modes, while preserving the symmetries of the quanton / cosmological relative ratios with time relative ratio ,the Planck time must be altered , not only this but the smooth

COMPLEX parameter transition between different phases must be ensured.

For inflation of the form (a) $\propto t^{\frac{1}{2}}$, the variation the parameter/ degree of freedom /time relationship takes the form

$$Dof_{r_q} = \frac{3}{8} = Dof_{\omega} = \frac{1}{2} Dof_t \quad \text{or} \quad Dof_t = Dof_{r_q} + Dof_{\omega} = \frac{3}{4}$$

Dof_{V_q} (quanton volume)= $3 \text{Dof}_{r_q} = \frac{9}{4} \text{Dof}_t$,
 $\text{Dof}_{V_u} = 4 \text{Dof}_{r_q} = \frac{3}{2} \text{Dof}_t$,
 Dof_{r_u} (universe radius) = $\frac{1}{3} \text{Dof}_{V_u} = \frac{1}{2} \text{Dof}_t$
 Which requires Planck time to be $t_p = \frac{t_0}{(8.08 \times 10^{60})^{\frac{2}{3}}} = 1.08 \times 10^{-23}$ sec so as to preserve the symmetry between parameter relative ratios and that of time.

While inflation of the form (a) $\alpha t^{\frac{1}{2}}$ (constant inflation at $v=c$) requires Planck time to become $t_p = t_0(8.08 \times 10^{60})^{\frac{1}{3}} = .00217$ sec

The very close match between quanton , cosmological parameter ratios to that of time ($\sqrt[2]{8.08 \times 10^{60}}$ per Degree of freedom) suggests a uniform inflationary history of the nature $r_u = K_{ru} t^{\frac{2}{3}}$ as discussed before Should there be any deviation from this model , the deviation would have been manifested directly in the form of significant variation between the quanton / cosmological relative ratios and that of time , as an example of this is the radiation dominated era (up to 380 k years) which is defined as

$a \propto t^{\frac{1}{2}}$ under such conditions $r_u = K_{ru} t^{\frac{1}{2}}$, $V_u = K_{ru} t^{\frac{3}{2}}$ and the cumulative ratio of present day to Planck era's volume of the universe $(\frac{V_{uo}}{V_{up}}) =$

$(\frac{V_{uo}}{V_{ur2}})(\frac{V_{ur2}}{V_{ur1}})(\frac{V_{ur1}}{V_{up}})$ where V_{ur1} , V_{ur2} the volume at the start and end of radiation dominated era – V_{ur1} maybe taken to be identical to Planck era volume) , the value of the ratio $\frac{V_{ur2}}{V_{ur1}} = (\frac{t_{r2}^{\frac{3}{2}}}{t_{r1}^{\frac{3}{2}}})$ is smaller than the that of the uniform model $\frac{V_{ur2}}{V_{ur1}} = (\frac{t_{r2}^2}{t_{r1}^2})$, any ratio that deviates from the second order variation is going to impact the overall ratio of the universe's volume and deviates substantially from the closely matched value of the time ratio.

This is particularly true for the case of primordial time where for small values of (t), the deviations become considerably high , and the other alternative to preserve the symmetry of ratios is to allow for the use of Another value of Planck time as illustrated previously

12. INFLATIONARY THEORY AND STANDARD COSMOLOGY VERSUS QUANTON MODEL

as the quanton model differs in some aspects from existing inflationary theory and standard cosmology , it would be beneficial to highlight the major differences between both of them Table.3 illustrates main timeline differences between the inflationary theory / standard cosmology and the quanton model

Table 3. Time line differences between inflationary theory /standard cosmology and quanton based model

Time /event	Inflationary theory	Single quanton model
t=0	Singularity event	packet state (energy nonvarying in space or time) $E_p = E_s E_t$
$t < t_s$ (1.15×10^{-164} sec)	No data	Free energy dominated $E_q = E_{sf} E_{tf}$
$t = \square_{\square}$	No data	Evolution of single quanton $\square_{\square} = (E_{sf} E_{tc})(E_{sc} E_{tf})$
$t_s < t < t_p$ (5.39×10^{-44} sec)	No data	-Quanton splitting and inflation , subsequent release of radiation energy
$t = \square_{\square}$	the threshold of laws of physics	
$10^{-32} > t > 10^{-36}$	Hyper Inflationary period	-uniform decelerative inflation
$t > 10^{-32}$	Start of nucleosynthesis	same as standard cosmology
Radiation dominated era	Slow inflation (a) $\alpha t^{\frac{1}{2}}$	uniform decelerative inflation Inflation under a comoving rate

Time /event	Inflationary theory	Single quanton model
Matter dominated era t<9 G years inflation	decelerating inflation (a) $\alpha t^{\frac{2}{3}}$	$\frac{dr_u}{dt} > c$, the universe is spherical in shape $r_u \propto t^{\frac{2}{3}}$, $\frac{dr_u}{dt} \propto t^{-\frac{1}{3}}$
Dark energy dominated inflation	Accelerated inflation (a) $\alpha e^{H_0 t}$	Inflation under a constant rate $\frac{dr_u}{dt} = c$, the universe moves to a shell like shape

It must be noted that when talking about energy density as a primary parameter its uniform expansion corresponds to a uniform volumetric expansion of space fabric as a quantum gas model The following Table 4. illustrates major differences between standard cosmology and the quanton model

Table 4. Major differences between standard cosmology and quanton model (b)

Parameter	Standard cosmology	Quanton based model
Radiation	Dominant energy in and immediately after Planck era	Radiation is a by-product of quanton expansion
Origin of the universe inflation	No consensus: quantum fluctuations /dark energy /radiative pressure	Self interaction of space and time varying energy fields which lead to quanton expansion and splitting
Nature of inflation	uniform spatial inflation throughout (Hubble parameter is an absolute measure of the universe's inflation)	uniform volumetric inflation (Hubble parameter allowed to have relative values)
Representative Measurement of the universe's inflation	Supernova type Ia red shift	CMB red shift
Shape of the curvature	Determined by density parameter	always satisfies spatial symmetry which implies being either a sphere of shell in shape
Role of energy density	Determines the inflationary model	Can only control the rate of inflation The quanton model evolved to expand (up till now)
Decelerating inflation era	Due Matter dominated era	While expanding as a sphere : rate of increase of universe volume $\propto (t)$, while the rate of change of its radius $\propto (t^{-\frac{1}{3}})$
Accelerating expansion of the universe	Dominance of dark energy	refer to section : inflationary history of the universe
Inflationary fate determinant factor (perpetual expansion / eventual contraction)	Perpetual expansion when density less than critical density	Interactions inside and outside the quanton determine the fate of the inflation

13. DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, upon request or alternatively it can be downloaded via one of the following links

https://drive.google.com/file/d/1RSdswcJLUnYOTmc4__GxVomr_556D7Ri/view?usp=sharing
<https://archive.org/details/calculations-24>

14. DISCUSSION

This model had provided a profile for quanton and cosmological parameter variation with time through the degree of freedom approach and one of the most significant consequences is the development of (Einstein –De sitter) inflationary model using this method as an alternative to Friedmann equations in a *closed universe cosmology*

Through fixed parameter time constants a truly nonaccelerating universe had been proposed , furthermore an answer to the (cosmological horizon problem) was provided in the form of synchronized quanton and consequently cosmological parameters

15. CONCLUSIONS

- a. Quanton splitting is the mechanism of allowing four dimensional energy density to expand in three dimensional space with minimal losses.
- b. Relative ratios of quanton and cosmological parameters like quanton number, its radius, angular frequency, universe volume , and its density are remarkably related due to the energy density- degree of freedom relationship.
- c. Synchronization of the quanton's parameters (and subsequently the universe's) happens as the time variation is split anti symmetrically between space varying (quanton radius) degree of freedom and time varying (angular frequency) degree of freedom.

ETHICAL STATEMENT

The author declares that this work fully complies with the ethical guidelines as had been stated by the journal

COMPETING INTERESTS

Author has declared that no competing interests exist.

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